

Presentation 30 MW Wind Park at Urirama

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Parliament
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Introduction

In an effort to meet the Aruban Government Vision to double the current wind energy grid penetration, W.E.B. Aruba N.V. has contracted KEMA and CRA to assist WEB in the technical and economic evaluation of the project.

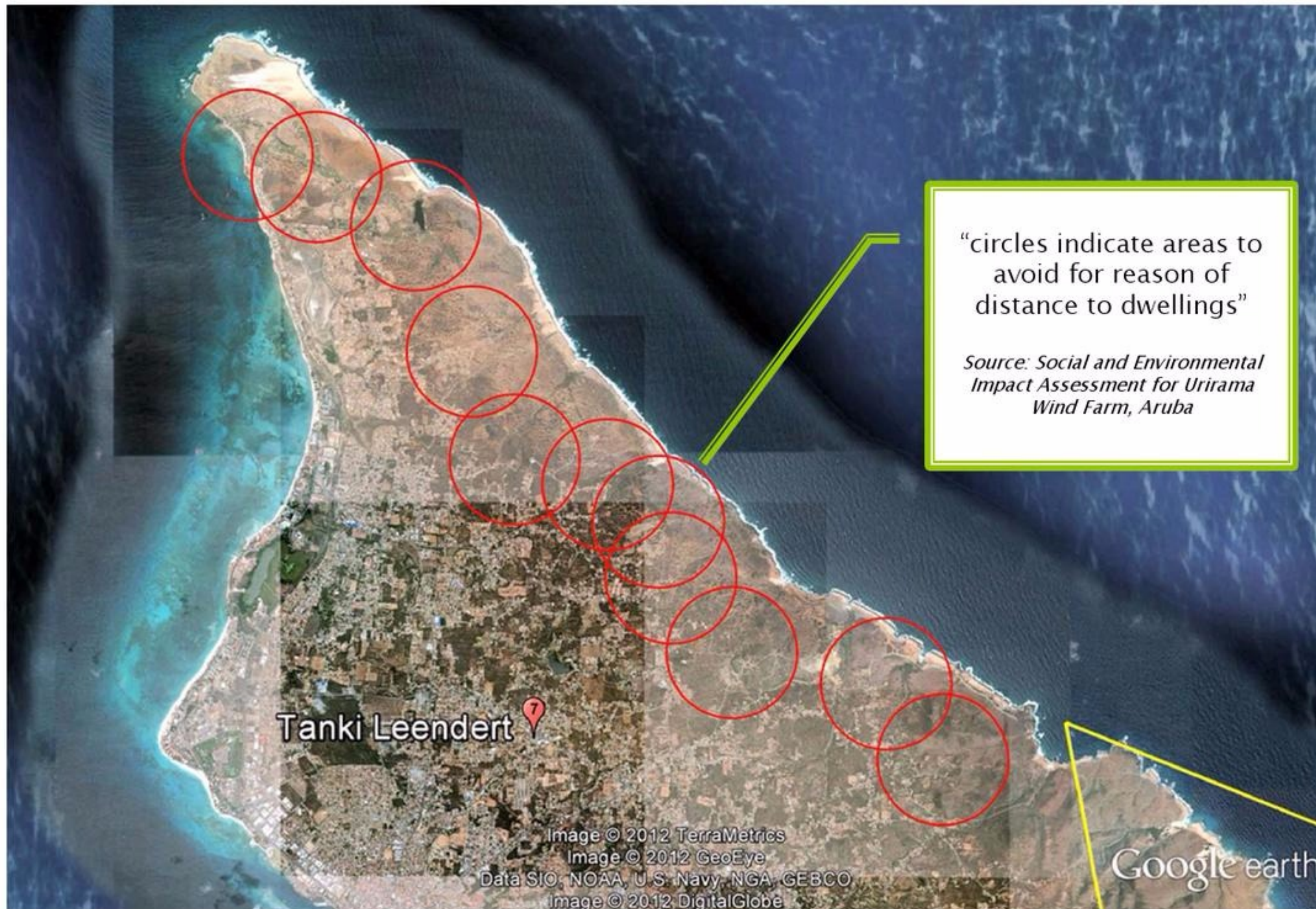
This was done in an effort to mitigate potential severe operational impact and consequences that this project may impose on the power production reliability, with all due consequences for WEB and its customers.



Base Scenario

- ▶ Expansion of wind farm with 30 MW, to be installed at Urirama
- ▶ WEB generation park, except GT, on HFO fuel
- ▶ Total wind based on minute interval measured at Vader Piet and metering mast at Urirama (Jul.–Nov. 2011)
- ▶ Existing dispatch scenario with Wind Park Vader Piet

Potential Wind Park Location



Wind Park Vader Piet Expansion

- ▶ Technical implications
 - Greater wind fluctuations > power output fluctuations
- ▶ Economical implications
 - Higher investment due to greater back-up requirements
 - Higher investment for grid connection

Wind Park at Urirama

- ▶ Technical advantages (vs. Vader Piet)
 - Wind resource availability
 - Wind delay factor (approx. 15 min.)
- ▶ Economic advantages (vs. Vader Piet)
 - Less back-up requirement
 - Lower cost grid connection

Wind Delay Factor

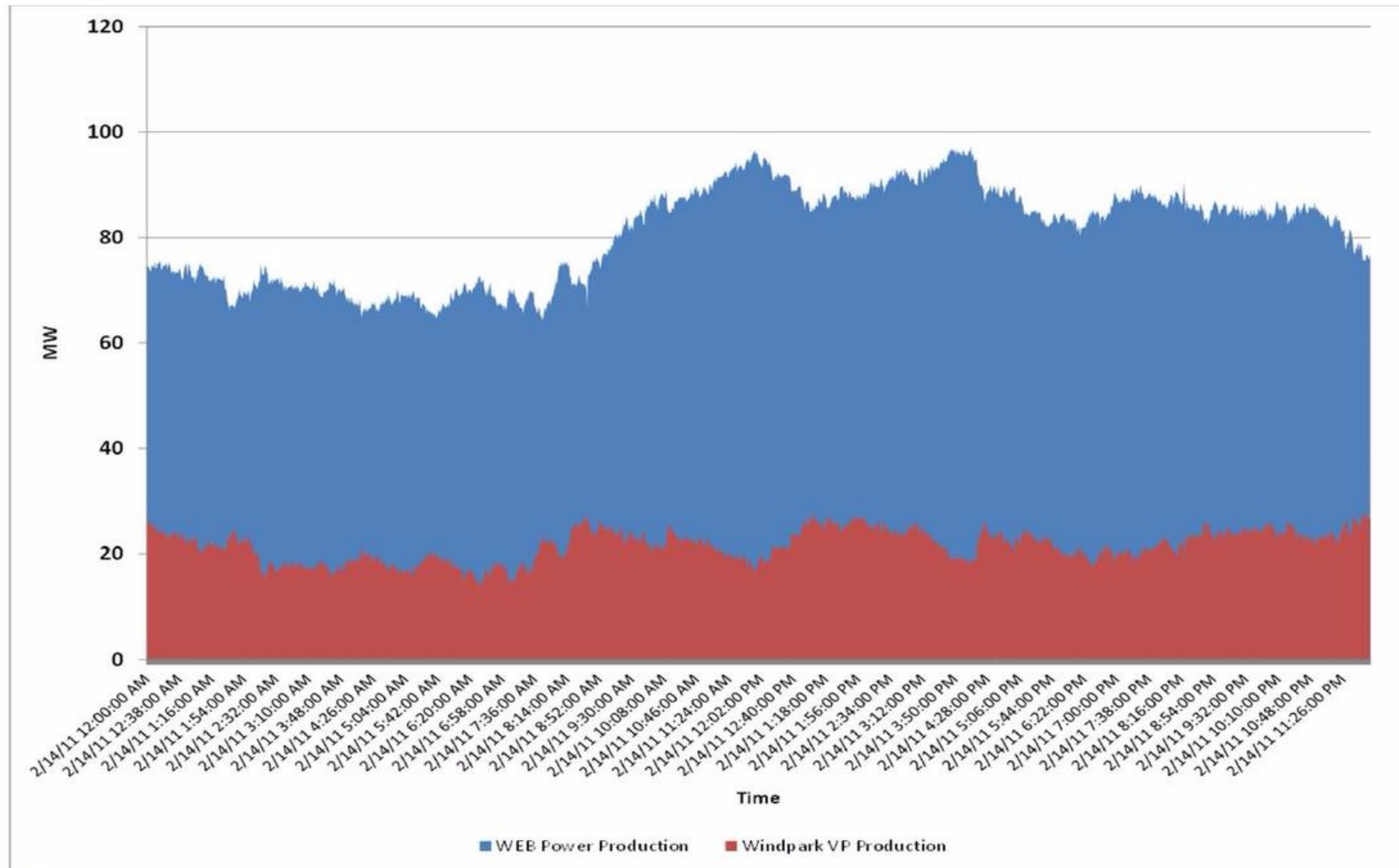


Wind Power Fluctuations

- ▶ All calculations based on the wind power data of Vader Piet and 5 months measurements at Urirama
- ▶ Historical measurements at Vader Piet
 - Minimum grid penetration is 0%
 - Average grid penetration is 12% (*based on 103 MW demand*)
 - Maximum (peak) grid penetration is 35% (*based on 80 MW demand*)
- ▶ The largest 15 minute decrease in wind power output measured is 35 MW
- ▶ 12 MW Fast response required (<1 minute fluctuations)
- ▶ 35 MW Total spinning required (> 1 minute fluctuations)

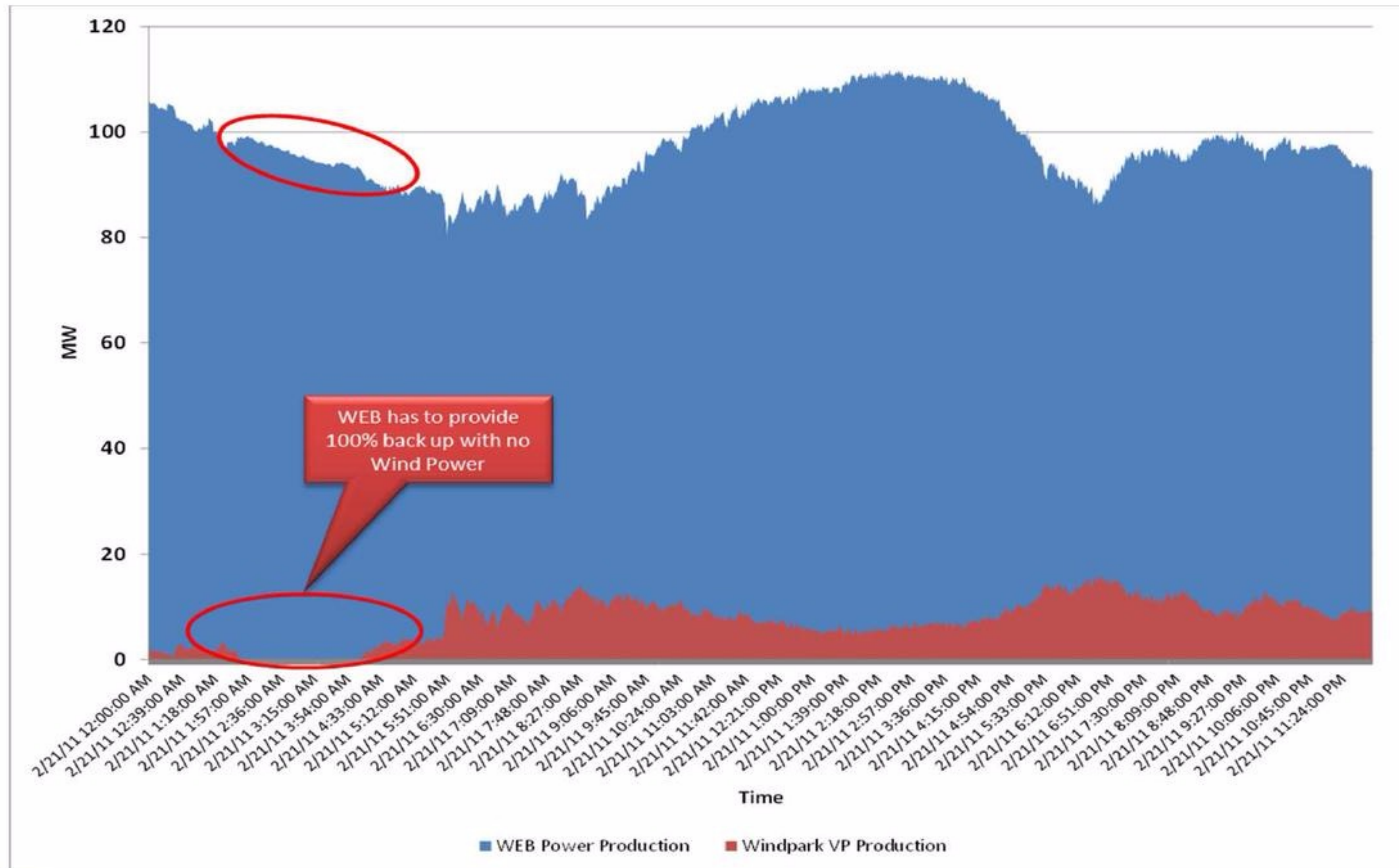
Wind Power Fluctuations (24 hrs.)

Relatively Constant Wind Power (sampling time= 1 min.)



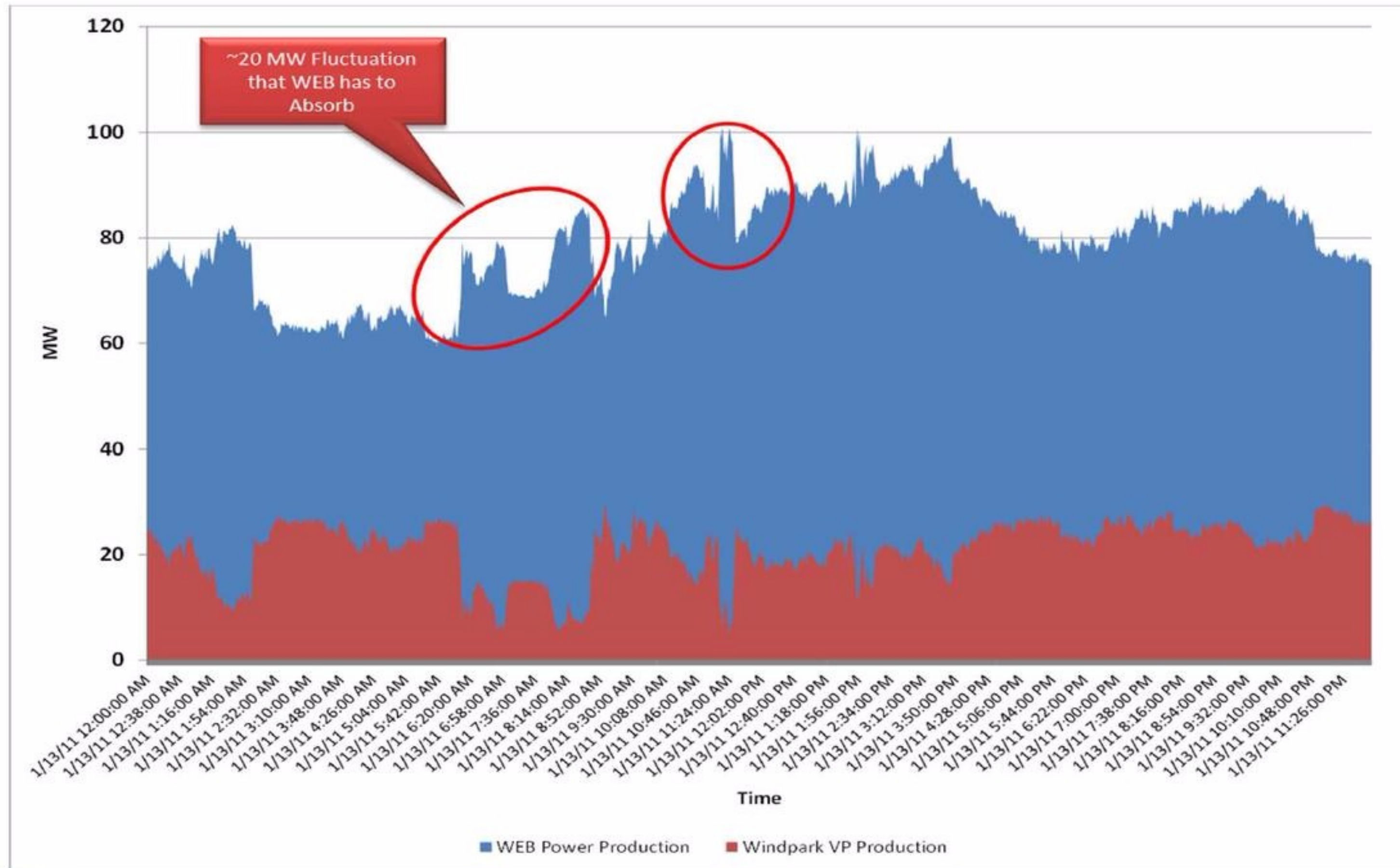
Wind Power Fluctuations (24 hrs.)

Relatively Low Wind Power (sampling time= 1 min.)



Wind Power Fluctuations (24 hrs.)

Relatively High Wind Power Fluctuation (sampling time= 1 min.)



Wind Power Curtailment

Wind curtailment is the amount of power generated by wind turbine generators that cannot be absorbed by the grid in a reliable manner.

It is the limitation put on a wind park in order to guarantee sufficient spinning reserves within Power Generating Plant and/or to mitigate sudden power increases during stormy weather conditions.

This is generally expressed in percentage

Wind Power Curtailment

- ▶ On HFO total wind curtailment will be approx. 6–11%
 - Even higher (up to 13%) with PV and Waste-to-Energy
 - Curtailment for Uirama ~ 25%
- ▶ On HFO it may occur up to 17 times a year that the required spinning reserve will be less than 35 MW. This may lead to partial/full blackout.
- ▶ On natural gas as fuel wind curtailment will be approx. 1–3%
- ▶ On natural gas as fuel it may occur twice a year that wind power decrease cannot be compensated by spinning reserve

Automation

Minimum requirements:

- ▶ WEB power production park to be completely automated
 - Load sharing required by all operating units to make up for wind power fluctuations
 - All Recips and TG's need to be automatically controlled
 - Auxiliary systems need to be automatically controlled
- ▶ Automation to be tailor made (adapted) to fit WEB operations philosophy
 - Training of operators required
- ▶ Batteries (20 MW/15 min)
- ▶ Gas Turbine (Diesel)
- ▶ Wind farms power increase rate must be controlled by WEB
- ▶ Short term (15 min.) wind forecast system required

Possible options

- ▶ Grid load shedding (partial/full blackout)
- ▶ Air-conditioning load shedding



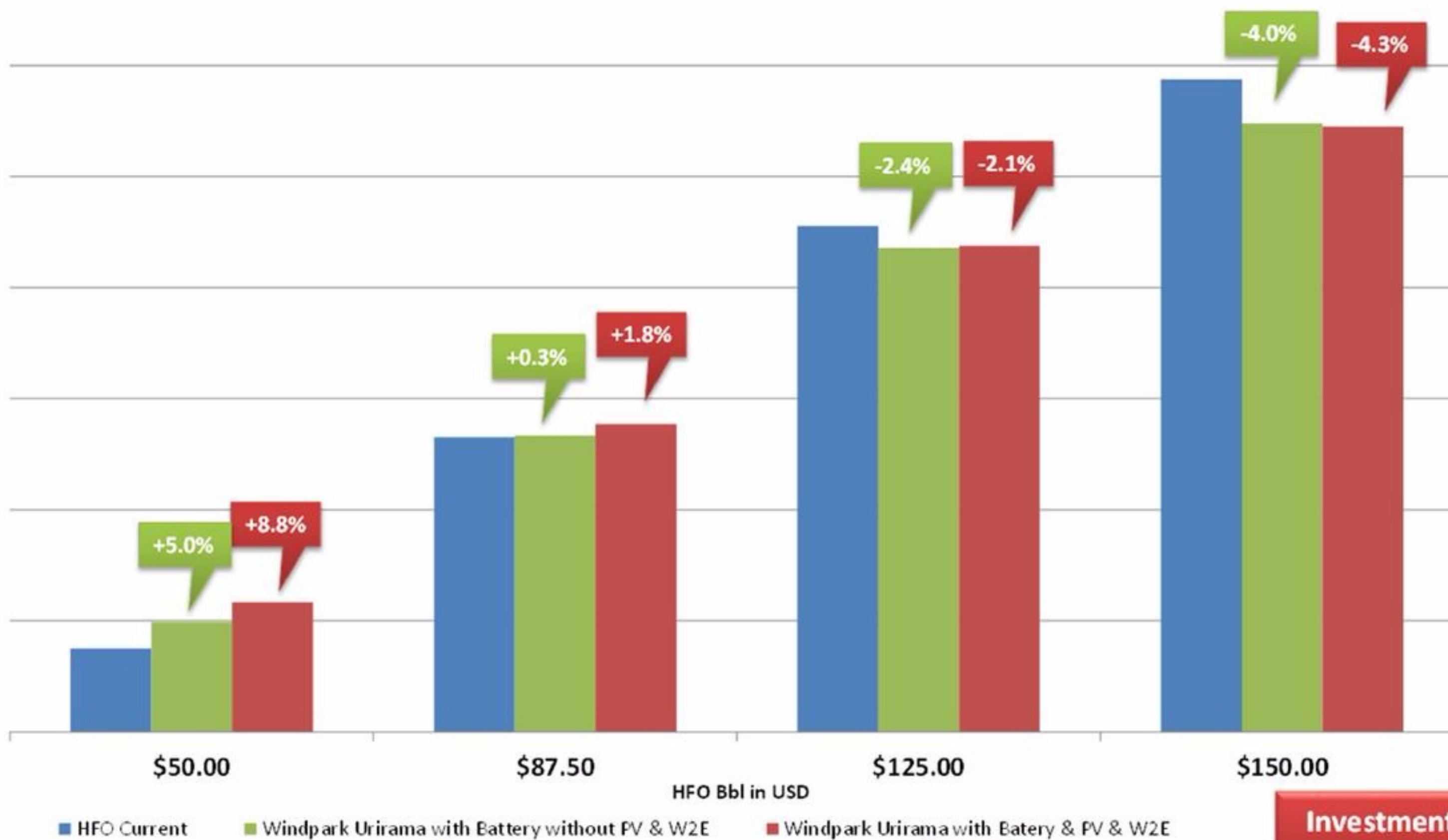
Economics – 30 MW WP Urirama

Principles:

- ▶ Base case after MEEIP (Major Energy Efficiency Improvement Project)
- ▶ Purchase price used for base case is same as Wind Park Vader Piet
- ▶ 25% Wind curtailment without penalty cost
- ▶ Wind scenario based on actual wind production data of 12.5 MW Avg. (2010, 2011)
- ▶ Water production losses/gain are not accounted for in calculation
- ▶ Total investment of 40 MM USD.
 - Includes battery back up (20MW/15min) 25 MM USD (HFO scenario only)
- ▶ Extra maintenance cost for RECIP 1&2 due to ~50% increase in start/stop not accounted for

Production Cost on HFO scenario

Power Purchase price WP Urirama same as WP Vaderpiet



BE \$86

BE \$99

Investment WEB
40 MM USD

Conclusions (HFO)

- ▶ On HFO an additional wind farm of 30 MW is technically feasible provided:
 - Spinning reserve of 2 steam turbines/2 boilers and 3 Recip III on minimum output required
 - Boiler/steam turbine load cycling will triple
 - The risk for trips and maintenance of boilers will probably increase
 - An online washing system installed for Recips 1 – 10
 - An advanced dispatch automation system
 - Recips 1 – 6 start/stop sequence will increase by ~50%
 - Reduction in equipment lifetime
 - Increased maintenance cost
 - Wind curtailment for WP Urirama will be higher (~25%) compared to WPVP (2%)
 - 20MW/15min Battery back-up or similar required
 - Without battery:
 - The number of starts of the gas turbine will be approx. once every 2 days and load shedding (partial/full blackout) once in 3 weeks

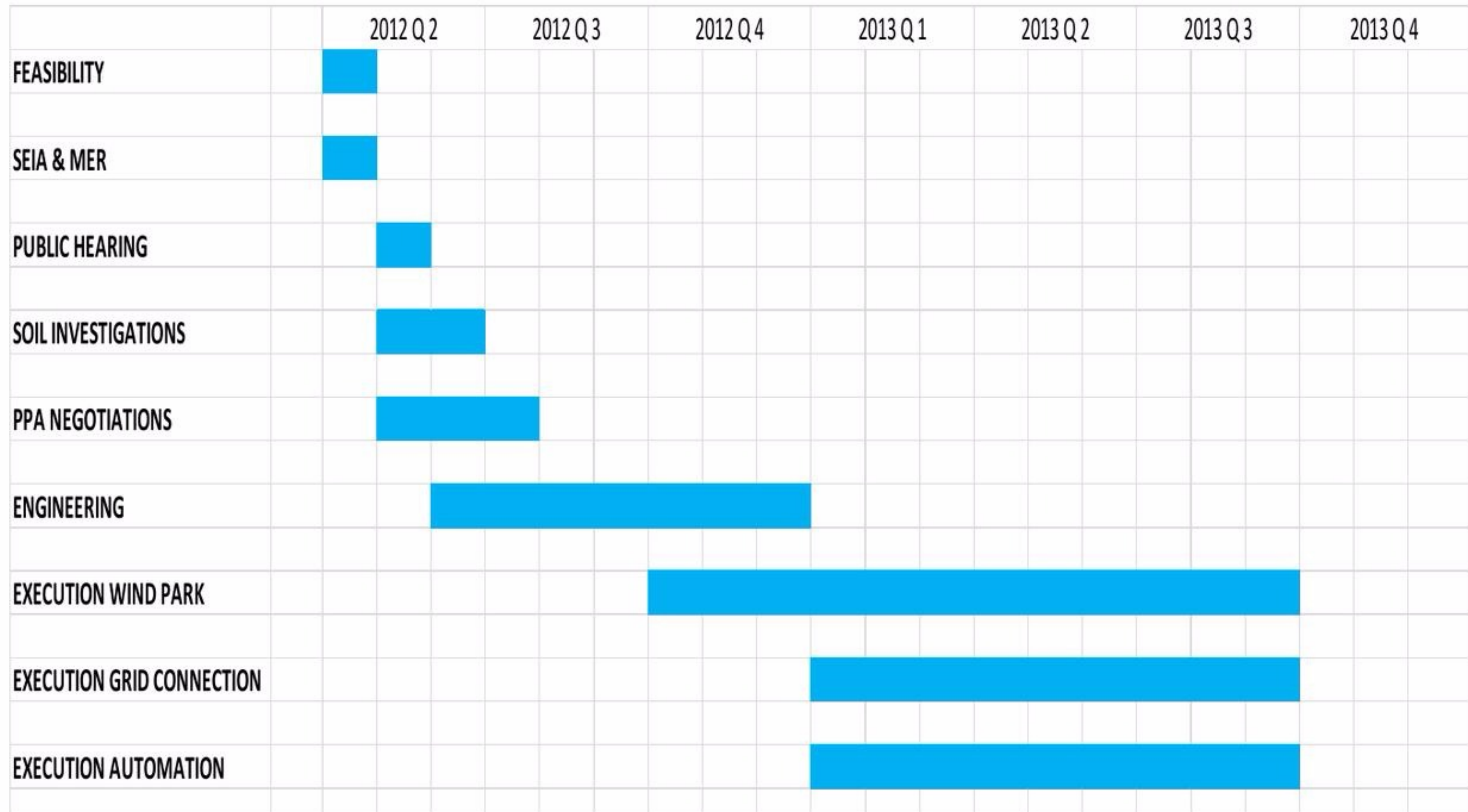
Conclusions (NG)

- ▶ On NG an additional wind farm of 30 MW is technically feasible under conditions:
 - Wind curtailment will be low ($<4\%$).
 - Extensive dispatch automation of WEB generators is required. Also the wind farms need to be included
 - Recip generators to compensate for wind power fluctuations
 - Storage battery (20 MW/15 min) is not required
 - The gas turbine will be started 3–4 times a week

Final Conclusion

- ▶ Technically feasible
- ▶ Mitigating effect on impact of future HFO cost increases
- ▶ On HFO economic incentive to customers marginal at current fuel prices
- ▶ On natural gas no economic incentive to customers
- ▶ Operation philosophy will have to change
- ▶ Quality/reliability of power supply may decrease
- ▶ Decrease carbon footprint (HFO only)

Preliminary Planning



Questions

